

## LOW-IMPEDANCE, LOW-HARMONIC SPRING CLIPS

### CROSS REFERENCES TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. provisional application No. 62/906,574, filed on Sep. 26, 2019, which is incorporated by reference.

### BACKGROUND

[0002] Electronic devices, such as portable computing devices, tablets, desktops, and all-in-one computers, cell phones, wearable computing devices, storage devices, portable media players, navigation systems, monitors and other devices, have become ubiquitous in recent years.

[0003] These electronic devices can include wireless communication circuits and components, such as circuits and components for Wi-Fi, cellular, Bluetooth, and other communication protocols. These circuits and components can include antennas and other waveguides that can be used for transmitting and receiving wireless signals.

[0004] These electronic devices can also include various enclosure components for a device enclosure or housing. These enclosure components can be metallic or otherwise conductive. The various enclosure components can be electrically connected to each other and grounded. The connections among these various enclosure components can have a high impedance, particularly at high frequencies. These enclosure components can be in proximity to the antennas and other waveguides of the wireless communication circuits.

[0005] In this arrangement, wireless signals on the antennas can couple onto the various enclosure components. To the extent that an enclosure component is grounded, this might not cause a problem. But since the connections among these various enclosure components can exhibit a high-impedance, high-harmonic behavior (particularly at high frequencies), the wireless signals on the antennas or other waveguides can generate voltages on some of the enclosure components and the connections or junctions among them. In particular, harmonics, such as the third harmonic, of signals (or the carrier portion of the signal) can be generated at these junctions. This frequency dependent behavior can also be nonlinear. This can pose problems, for example in attempting to comply with various regulatory standards and to limit Radio Frequency Interference (RFI) between two or more radios on the same device. It can also degrade the transceiver signals and lead to an increase in data transmission errors.

[0006] Thus, what is needed are components for connections that provide a reliable, low-impedance, low-harmonic path between various enclosure components of electronic devices.

### SUMMARY

[0007] Accordingly, embodiments of the present invention can provide spring clips that provide a reliable, low-impedance, low-harmonic path between various conductive enclosure components of electronic devices. These spring clips can include a low-impedance connection on each of two ends, where each end physically and electrically connects to an enclosure component of an electronic device. This can reduce an impedance between enclosure components and

reduce the amplitude and harmonics of signals coupled onto them from a nearby antenna or other waveguide.

[0008] An illustrative embodiment of the present invention can provide spring clips having contacting portions at ends of the spring clips, where the contacting portions include two or more raised surfaces or spring contact junctions. Each spring clip can include a plate portion on a first end, the plate portion having an area for contacting a surface of a first enclosure component and having a first width in a first direction. The contacting portion having the two or more spring contact junctions for contacting a second enclosure component can be located on a second end. A connecting portion extending from the plate portion to the contacting portion in a second direction can join the two. The first direction can be orthogonal to the second direction. The connecting portion can have a second width in the first direction, wherein the second width is narrower than the first width.

[0009] In these and other embodiments of the present invention, the plurality of spring contact junctions can comprise two spring contact junctions. The two spring contact junctions can be adjacent or nearby and in a line in the first direction. In these and other embodiments of the present invention, the two spring contact junctions can be adjacent or nearby and in a line in the second direction. In these and other embodiments of the present invention, the two spring contact junctions can be adjacent or nearby and in a line in a direction that is between the first and the second direction. In these and other embodiments of the present invention, for each spring clip, the plurality of spring contact junctions can comprise three spring contact junctions. These three spring contact junctions can be adjacent and in a line in the first direction. In these and other embodiments of the present invention, the three spring contact junctions can be adjacent and in a line in the second direction. The three spring contact junctions can instead be arranged in a triangle or other pattern. Using embodiments of the present invention that include two raised surfaces or spring contact junctions can reduce harmonic noise power generated by more than 6 dB. Using additional spring contact junctions can further reduce impedance and the resulting noise power. For example, using embodiments of the present invention that include three spring contact junctions can reduce harmonic noise power generated by more than 9 dB.

[0010] These spring clips having two or more spring contact junctions can provide other advantages in addition to a low-impedance, low-harmonic performance. For example, since two spring contact junctions are available to form an electrical connection, the presence of dust or other contaminant between one spring contact junctions and an enclosure component might not render the spring clip ineffective. This redundancy can lead to a more robust, reliable connection provided by the spring clip.

[0011] Also, two spring contact junctions providing two points of contact can provide a more mechanically stable connection between a spring clip and an enclosure component. Moreover, the force between each spring contact junction and enclosure component can be reduced, thereby reducing wear on the adjacent surfaces.

[0012] In these and other embodiments of the present invention, spring clips can be used to electrically connect various housing or device enclosure components. For example, they can be used to connect support plates (which can provide support for flexible circuit boards, displays,